ROYAL ASTRONOMICAL SOCIETY.

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Dr. LEE, Vice-President, in the Chair.

Total Solar Eclipse of September 7, 1858.

The following copy of a communication from the Admiralty to the senior naval officer on the coast of Brazil relative to the total eclipse of the sun, which will be visible in South America on the 7th of September next, has been forwarded by the Secretary of the Royal Society:—

"*Admiralty, May* 1, 1858.

"Sir,—I am commanded by my Lords Commissioners of the Admiralty to acquaint you that as the total eclipse of the sun, on the 7th of September next (not visible in Europe), will be visible on the coast of Brazil, and as the accurate observation of such eclipses may prove of high scientific interest, their Lordships are desirous that a passage in one of H.M. Ships from Rio de Janeiro to St. Paul's may be afforded to any English astronomer who may go to Brazil, for the purpose of making such observations, provided the exigencies of the service will admit of a steam-vessel being employed for the purpose.

"The astronomer may arrive at Rio de Janeiro in August next, and the steamer should convey him with his instruments to St. Paul's or St. Catherine's, or to such other port on that part of the coast, as may be most convenient; he should be afforded every assistance and facility for landing and erecting his instruments; and after his observations are completed, the vessel should take him back to Rio de Janeiro.

(Signed) "H. CORRY.

"*The Senior Officer of H.M. Ships and Vessels, Rio de Janeiro.*"

Observations of Comet V. 1857, *and of Comet I.* 1858, *taken with the Equatoreal of the Liverpool Observatory.* By John Hartnup, Esq.

Comet V., 1857.

1857.	Green. M.T. h m s	Comet's R.A. h m s	Log.$\frac{p}{P}$	N.P.D. ° ′ ″	Log.$\frac{q}{P}$	Star of Comp.	
Sept. 25	7 4 38·5	13 45 44·38	+ 8·605	77 33 19·9	− 9·8813	B.A.C.	4721
	7 42 36·7	13 45 43·66	+ 8·611	77 35 6·9	− 9·8932	—	—
28	7 35 57·9	13 43 47·73	+ 8·606	80 42 43·8	− 9·8991	—	4559
	7 41 59·5	13 43 47·90	+ 8·605	80 43 12·5	− 9·9006	—	5359

Comet I., 1858.

1858.							
Feb. 6	8 19 22·8	1 58 3·43	+ 8·480	83 59 16·4	− 9·8772	—	684
	8 37 22·7	1 58 6·12	+ 8·508	84 0 12·1	− 9·8795	—	—
	8 55 22·9	1 58 8·61	+ 8·531	84 1 4·2	− 9·8818	—	—
8	6 54 30·2	2 4 52·85	+ 8·273	84 54 3·8	− 9·8805	—	760
	7 24 29·7	2 4 57·19	+ 8·365	84 55 18·9	− 9·8823	—	—
	7 54 29·4	2 5 1·37	+ 8·435	84 56 36·9	− 9·8844	—	—
15	7 18 23·2	2 28 25·57	+ 8·359	92 25 45·0	− 9·9134	—	823
	7 33 22·7	2 28 27·60	+ 8·397	92 26 8·0	− 9·9129	—	—
	7 52 22·5	2 28 29·96	+ 8·438	92 26 59·6	− 9·9122	—	—
16	7 7 42·3	2 31 38·25	+ 8·331	93 17 53·9	− 9·9174	—	778
	7 22 41·6	2 31 39·92	+ 8·373	93 18 25·9	− 9·9167	—	—
	7 37 41·6	2 31 42·09	+ 8·409	93 19 2·6	− 9·9161	—	—

The observations are corrected for refraction. The corrections to be applied for parallax in time and arc are represented by p and q. P is the equatoreal horizontal parallax. The following are the assumed mean places of the stars of comparison:—

For 1857, *Jan.* 0.

	R.A. h m s	N.P.D. ° ′ ″	Authority.	
B.A.C. 4721	14 7 12·68	76 22 4·27	British Association Catalogue	
— 4559	13 32 31·70	78 31 34·55	,,	,,
— 5359	16 0 48·28	79 43 25·33	,,	,,

For 1858, *Jan.* 0.

B.A.C. 684	2 5 28·61	81 49 16·33	Greenwich Catalogue, 1850	
— 760	2 20 36·77	81 10 43·65	,,	,,
— 823	2 33 57·47	91 18 6·48	British Association Catalogue	
— 778	2 24 56·20	91 39 49·22	,,	,,

Observations of Saturn. By William Lassell, Esq. F.R.S.

"On going into the observatory on the 17th ult. a little before nine o'clock, I was struck with the fine definition of *Saturn*, with the 20-foot equatoreal (mirror A), power 430. Indeed, so fine was it by transient glimpses, that I scrutinised it for some time with this power and 650, aperture 20 inches. The vision, in point of definition, seemed to be faultless, and judging by the best glimpses, appeared quite equal to the best definition I have ever seen with any telescope. I consider some of these moments to have afforded me one of the grandest exhibitions of the planet I have ever seen. But they were too transient to enable me to survey with the requisite attention half the points which arrested my notice.

"I did, however, observe the intense blackness and sharpness of the shadow of the ball upon the ring and its angular outline. Its blackness amounted even to a contrast with the brown shade of the division between the rings A and B. Perhaps there would have appeared, had they been in the same juxtaposition, almost the same difference in intensity of shade as between the colour or shade of the ring C and the sky included in it.

"The projection of the shadow of the ball upon ring C, as well as B, I never saw more plainly; nor, indeed, the inner outline of C so distinctly marked out upon the included dark sky. The ring C appeared of one uniform grey tint. I do not, however, remember anything about its exterior outline, as to whether it was easily separated or distinguished from the inner surface of B. This point escaped my notice; but I remarked the extensive band-like shading of the greater part of the surface of B, deepest at or very near its inner edge, and traceable outwards, even to the extent of two-thirds of its breadth.

"The tracery upon the ball was more marked and diversified than I ever saw it; the principal dark belt was divided, and south of it were three other very narrow and pretty equally distant dark belts. Near the preceding limb, moreover, and a little south of the equatoreal dark belt, was a brighter portion, rather too large to be called a spot, yet sufficiently defined or marked out to be useful in determining the rotation of the planet, if one might be favoured with a more prolonged recurrence of so fine a state of atmosphere. The southern edge of the ball appeared to me to project by the smallest appreciable quantity beyond the imaginary line which would be necessary to complete the symmetry of the ring in that part.

"Lastly, I scrutinised with all the care which the circumstances would allow the whole breadth of ring A at both ansæ, with a view to detect, if possible, any division or well-defined mark or stripe upon its surface. I concluded that by my eye nothing in the slightest degree approaching the nature of a division could be detected, and I could not gain the impression of more than a very slight shade upon it similar to what I observed

at Malta. The comparatively ample breadth given to this ring with a power of 650, and an aperture of 20 inches, together with its sharp definition, were, I thought, favourable circumstances for this scrutiny.

"But the time was very short, for light clouds soon came on, and what I have here recorded had to be observed during the tranquil moments which occurred in a short half-hour of observation. Nevertheless, I have had no opportunity so favourable during the winter; and I can scarcely help expressing in conclusion, what is indeed a useless regret, that the state of the atmosphere here will so rarely permit this telescope to be employed to its full aperture and power. The definition on the 17th was such as to persuade me that, had the fine glimpses been less transient, somewhat more of the phenomena of *Saturn* than I have ever yet seen might have been revealed.

"*Bradstones, Sandfield Park, Liverpool, May* 6."

Results of the Observations of Small Planets, made at the Royal Observatory, Greenwich, in the month of April, 1858.

(*Communicated by the Astronomer Royal.*)

Hebe.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 9 14 35 5·4	15 47 14·45	88 13 30·40
10 14 30 42·3	15 46 47·15	88 6 10·44
13 14 17 24·0	15 45 16·37	87 44 13·10
17 13 59 21·1	15 42 56·73	87 15 38·34
19 13 50 12·4	15 41 39·60	87 1 38·54
20 13 45 36·1	15 40 59·06	86 54 44·72
21 13 40 58·7	15 40 17·48	86 48 1·70
24 13 27 0·1	15 38 6·27	86 28 17·27
30 12 58 37·6	15 33 18·47	85 51 55·88

Eunomia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 3 8 58 2·2	9 45 36·60	89 18 34·16
10 8 29 13·8	9 44 19·35	89 0 9·60
13 8 17 14·5	9 44 7·74	88 53 37·11

Psyche.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 19 12 47 27·0	14 38 43·94	101 14 19·43
20 12 42 46·5	14 37 59·18	101 10 6·89
21 12 38 5·0	14 37 13·44	101 5 52·63
23 12 28 41·9	14 35 41·94	100 57 25·87
24 12 24 0·0	14 34 55·87	100 53 9·68
30 11 55 42·6	14 30 13·12	100 27 58·40

Melpomene.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 1 11 17 24·6	11 57 28·74	80 46 6·84
10 10 35 (0)	.....	79 48 41·47
13 10 21 9·5	11 48 23·07	79 33 1·65
15 10 12 1·2	11 47 6·32	79 23 37·45
17 10 2 57·5	11 45 54·27	79 15 2·76
19 9 53 59·1	11 44 47·52	79 7 21·10
20 9 49 31·9	11 44 16·16	79 3 47·31
21 9 45 5·7	11 43 45·72	79 0 29·11
22 9 40 41·2	11 43 17·05	78 57 19·96
23 9 36 18·1	11 42 49·79	78 54 22·39
24 9 31 56·1	11 42 23·66	78 51 41·61
26 9 23 16·3	11 41 35·58	78 46 57·40

Thalia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 13 11 58 19·8	13 25 49·35	84 57 53·51
17 11 38 46·0	13 21 58·50	84 55 13·20
19 11 29 2·3	13 20 6·34	84 55 0·03
20 11 24 11·6	13 19 11·35	84 55 13·76
21 11 19 21·7	13 18 17·29	84 55 35·15
22 11 14 32·4	13 17 23·69	84 56 8·04
23 11 9 44·4	13 16 31·44	84 56 54·26
24 11 4 57·0	13 15 39·87	84 57 52·47

Massilia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 1 13 33 3·0	14 13 29·45	103 26 8·27
10 12 50 5·4	14 5 53·73	102 43 42·82
13 12 35 32·4	14 3 8·00	102 28 4·81
15 12 25 48·5	14 1 15·66	102 17 24·92
17 12 16 2·9	13 59 21·56	102 6 37·36
19 12 6 17·4	13 57 27·58	101 55 41·69
20 12 1 24·6	13 56 30·47	101 50 15·54
22 11 51 39·1	13 54 36·51	101 39 17·55
23 11 46 47·0	13 53 40·11	101 33 49·28
24 11 41 54·9	13 52 43·84	101 28 20·49
30 11 12 53·1	13 47 16·60	101 56 14·87

Lutetia.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 10 9 29 43·3	10 44 58·77	77 19 31·64
15 9 8 8·3	10 43 3·00	77 14 48·45
15 8 51 20·5	10 41 58·63	77 14 3·26

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 1 11 35 59·3	12 16 6·48	93 50 30·97
10 10 52 44·6	12 8 13·71	93 18 43·87
13 10 38 34·2	12 5 50·63	93 9 3·42
15 10 29 12·1	12 4 20·10	93 2 59·18
17 10 19 54·4	12 2 53·93	92 57 13·96
19 10 10 42·1	12 1 33·24	92 51 54·77
20 10 6 7·7	12 0 54·69	92 49 21·96
21 10 1 34·6	12 0 17·32	92 46 57·80
22 9 57 2·5	11 59 41·07	92 44 38·19
23 9 52 32·4	11 59 6·76	92 42 24·70
24 9 48 3·3	11 58 33·50	92 40 20·95
26 9 39 9·1	11 57 31·02	92 36 29·12

Euterpe.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 3 8 28 28·7	9 15 58·21	71 51 13·11
10 8 4 13·9	9 19 15·26	72 10 15·09

Fortuna.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 1 9 52 25·7	10 32 15·92	82 27 2·06
3 9 43 36·9	10 31 18·72	82 19 42·78
10 9 13 32·7	10 28 45·46	81 58 44·29
15 8 52 48·7	10 27 40·88	81 48 15·01
19 8 36 41·1	10 27 16·81	81 42 32·38
20 8 32 42·8	12 27 14·42	81 41 25·82
21 8 28 46·0	10 27 13·54	81 40 29·75

Nemausa.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 19 9 26 34·3	11 17 18·22	82 30 27·07
20 9 22 30·7	11 17 10·50	82 25 7·54
21 9 18 28·7	11 17 4·39	82 20 2·30
22 9 14 28·8	11 17 0·35	82 15 13·51
23 9 10 30·6	11 16 58·13	82 10 35·36
24 9 6 34·0	11 16 57·37	82 6 19·72
26 8 58 45·7	11 17 0·89	81 58 26·07

Europa.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, April 10 8 55 46·1	10 10 55·93	72 49 39·63

April 24, *Psyche*. The reading of the telescope-micrometer has been increased 5 revolutions, of which the equivalent is 2′ 28″·01, added to observed N.P.D.

April 10, *Europa*. The pointer-reading in N.P.D. has been increased 5′.

Discovery of a New Comet.

Extract of a Letter from Mr. Bond to Mr. Carrington.

"Mr. Tuttle discovered a new Comet at this Observatory on the evening of the 2d instant. Its approximate position and motion were as follows:

May 3, $10^h\ 50^m$, Harvard M.T.

R.A., $9^h\ 53^m$	Daily Motion, $+4^m{\cdot}5$
Dec., $+35°\ 10'$	,, ,, $+0°\ 30'$

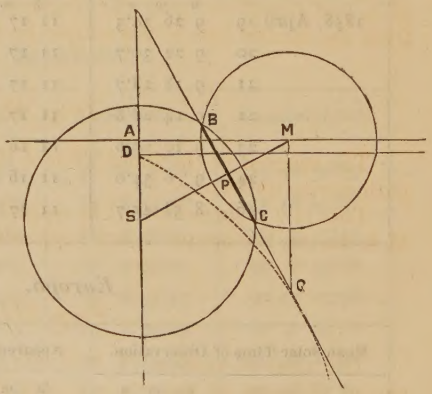
"It is a very faint object in the comet-seeker.

"*Observatory of Harvard College, May* 4, 1858."

On the Changes in the Direction and Length of the Line of Cusps during a Solar Eclipse. By Thomas Dobson, Esq., B.A., Nautical School, Royal Hospital, Greenwich.

Prop. I.

In a solar eclipse the line of cusps is always a tangent to a given parabola; and the right line joining the point of tangential contact and the moon's centre is perpendicular to the moon's apparent path across the sun's disk.



Let S A be the distance of the sun's centre S from the apparent path A M of the moon's centre M across the sun's disk; and B C the line of cusps, bisected in P by S M.

Let $AS = a$; $AM = y$; $SP = r$; the inclination of BC to $AM = \theta = \angle ASP$; s and m the semi-diameters of the sun and moon respectively. Then, $MP = a \sec\theta - r$; and

$$m^2 - (a\sec\theta - r)^2 = BP^2 = s^2 - r^2;$$

$$\therefore\ 2ar = a^2\sec\theta + (s^2 - m^2)\cos\theta \quad . \quad . \quad . \quad (1)$$

When $\theta = 0$, P will coincide with some point D in S A, such that $2a \,.\, SD = a^2 + s^2 - m^2 = 2ap$ suppose. Taking D for the

origin of rectangular co-ordinates, and D S for the axis of x, the equation to the line B C is

$$r = y \sin \theta + (p - x) \cos \theta;$$

or,

$$u = 2a\{y \sin \theta + (p - x) \cos \theta\} - a^2 \sec \theta - (s^2 - m^2) \cos \theta = 0 \quad (2)$$

And the equation to the line M Q perpendicular to A M is

$$y = a \tan \theta \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Therefore, if ξ, η, denote the co-ordinates of the point Q of intersection of the lines (2) and (3),

$$2\xi = a \tan^2 \theta \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and, by the elimination of θ,

$$\eta^2 = 2a\xi \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The locus of Q is, therefore, a parabola, of which D is the vertex, and D S the axis.

Now, by a well-known property of the parabola, the subtangent $= 2\xi = a \tan^2 \theta = \eta \tan \theta$, by (3) and (4); $\therefore$ the line of cusps B C touches the parabola at Q.

The same result might have been obtained by eliminating the variable parameter θ between the equations $u = 0$, and $\frac{du}{d\theta} = 0$; and so demonstrating that the parabola (5) is the envelope of the right line (2).

The magnitude of the guiding parabola will depend upon that of a, and therefore upon the distance of the place of observation from the central line of the eclipse on the earth's surface.

Prop. II.

The tangent of the inclination of the line of cusps to the moon's path varies uniformly.

This law is formularized in equation (3), the moon's motion in M A during the eclipse being supposed to be uniform.

Prop. III.

The rate of change of inclination varies directly as the apparent distance of the sun's centre from the moon's path; and inversely as the square of the distance between the centres of the sun and moon.

Let S M $= a \sec \theta = z$; then, from equation (3),

$$\frac{d\theta}{dy} = \frac{\cos^2 \theta}{a} = \frac{a}{z^2}$$

Hence, the inclination changes more rapidly at places more distant from the central track on the earth's surface; and, at every place of observation, is changing fastest at the middle of the eclipse.

Let B P = c = P C; then, to determine the length of the line of cusps corresponding to any given value of the lunar distance z, we have, from the triangle S B M,

$$2\,c\,z = \sqrt{(s+m+z)\,(s+m-z)\,(z+s-m)\,(z+m-s)} \quad . (5)$$

a formula well adapted for logarithmic computation.

The nature of the successive changes in length of the line of cusps during the progress of an eclipse might also be deduced from (5); but this is more easily effected by determining the progressive variations of (r), and thence deriving the corresponding changes in (c) by means of the relation

$$c^2 = s^2 - r^2 \quad . \quad . \quad . \quad . \quad (6)$$

which shows that (c) is a maximum when (r) is a minimum, and *vice versâ*.

Suppose the eclipse to be annular, and therefore s greater than m; then the laws which govern the changes in magnitude of the line of cusps, may be enunciated thus:—

Prop. IV.

At all places of observation for which a^2 is less than $s^2 - m^2$, but greater than zero, the distance between the cusps will increase from zero at the point of first contact, until it equals the moon's diameter, and will then decrease to a certain minimum length at the middle of the eclipse; after which it will pass through the same phases in a reversed order, increasing from the central minimum up to the maximum length, the moon's diameter, and then decreasing to zero at the point of last contact.

Prop. V.

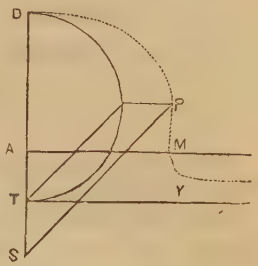
At all places for which a^2 is not less than $s^2 - m^2$, the distance between the cusps will increase from zero up to a certain relative maximum length at the middle of the eclipse, and then decrease to zero, without passing through an intermediate minimum value.

For the polar subtangent to the locus of P, we have,

$$\mathrm{S\,T} = r\frac{d\theta}{dr} = \frac{1}{2\,a\sin\theta}\,\frac{\{a^2 + (s^2-m^2)\cos^2\theta\}^2}{\{a^2 - (s^2-m^2)\cos^2\theta\}}$$

when $\theta = \pm\frac{\pi}{2}$; $r = \pm\frac{1}{0}$; and $\mathrm{S\,T} = \frac{a}{2}$.

Therefore the curve has a rectilinear asymptote T Y, parallel to A M, and bisecting A S in T.



Now, $ST = \frac{a}{2}$; and

$$TD = SD - ST = \frac{s^2 - m^2}{2a};$$

$\therefore$ by (1), $SP = ST \cdot \sec\theta + TD \cdot \cos\theta$;

which suggests an easy method of tracing the curve by means of a circle on the diameter T D, and a parallel ruler. The curve is divided symmetrically by S A, and lies wholly above the asymptote T Y.

Differentiating equation (1),

$$2a\frac{dr}{d\theta} = \sin\theta\left\{a^2\sec^2\theta - (s^2 - m^2)\right\}; \text{ and } \frac{d^2r}{d\theta^2} = a\sec^3\theta - r.$$

(1.) Let $a^2 < s^2 - m^2$. When $\frac{dr}{d\theta} = 0$, either,

$$\sin\theta = 0;\ \theta = 0; \text{ and } \frac{d^2r}{d\theta^2} = -\frac{s^2 - m^2 - a^2}{2a};$$

therefore, $r = SD = \frac{s^2 - m^2 + a^2}{2a}$ is a maximum; and consequently

$$2c = 2\sqrt{s^2 - r^2} = \frac{1}{a}\sqrt{4a^2s^2 - (s^2 - m^2 + a^2)^2}$$

is a minimum; or, $a^2\sec^2\theta - (s^2 - m^2) = 0$; $\frac{d^2r}{d\theta^2} = \frac{r}{a^2}(s^2 - m^2 - a^2)$;

$\therefore$ $r\sqrt{s^2 - m^2}$ is a minimum; and consequently $2c = 2\sqrt{s^2 - r^2} = 2m$, is a maximum.

In this second case, P coincides with M; for

$$\sqrt{s^2 - m^2}\cos\theta = r\cos\theta = a.$$

(2.) Let $a^2 = s^2 - m^2$; equation (1) becomes

$$r = \frac{a}{2}(\sec\theta + \cos\theta)$$

$$\therefore \frac{dr}{d\theta} = \frac{a\sin^3\theta}{2\cos^2\theta};\ \frac{d^2r}{d\theta^2} = \frac{a}{\cos^3\theta} - r;\ \frac{d^3r}{d\theta^3} = 3a\frac{\sin\theta}{\cos^4\theta} - \frac{dr}{d\theta};$$

and

$$\frac{d^4r}{d\theta^4} = \frac{3a}{\cos^3\theta}(1 + 4\tan^2\theta) - \frac{d^2r}{d\theta^2}.$$

When $\frac{dr}{d\theta} = 0$; $\theta = 0$; and $r = a$; $\frac{d^2r}{d\theta^2}$ and $\frac{d^3r}{d\theta^3}$ both vanish, but $\frac{d^4r}{d\theta^4} = 3a$; r is therefore a minimum; and $c = \sqrt{s^2 - r^2} = \sqrt{s^2 - a^2} = m$, is a maximum.

(3.) Let $a^2 > s^2 - m^2$.

Then, $a^2 \sec^2\theta > s^2 - m^2$; and when $\frac{dr}{d\theta} = 0$, $\theta = 0$; $\frac{d^2r}{d\theta^2} = \frac{a^2 - (s^2 - m^2)}{2a}$ is positive. Hence, in this case also, when $\theta = 0$, r is a minimum, and consequently $2c$ is a maximum.

Prop. VI.

When the eclipse is total, the nature of the changes of the distance between the cusps is the same as in Prop. V.

(1.) Let $s = m$; the only case requiring consideration is $a^2 > s^2 - m^2$, or > 0. When $\frac{dr}{d\theta} = 0$, $\theta = 0$; $\frac{d^2r}{d\theta^2} = \frac{a}{2}$; $r = \frac{a}{2}$ is a minimum; and $\therefore$ $2c$ a maximum.

(2.) Let $s < m$; then $2ar = a^2 \sec\theta - (m^2 - s^2)\cos\theta$;

$$2a\frac{dr}{d\theta} = \sin\theta \cdot \{a^2\sec^2\theta + (m^2 - s^2)\}; \quad \frac{d^2r}{d\theta^2} = a\sec^3\theta - r.$$

When $\frac{dr}{d\theta} = 0$, $\theta = 0$; $r = \frac{a^2 - (m^2 - s^2)}{2a}$, and $\frac{d^2r}{d\theta^2} = \frac{a^2 + m^2 - s^2}{2a}$ is always positive; $\therefore$ r is a mininum, and $2c$ is a maximum.

Observations of the Solar Eclipse of March 15, 1858, *made at the Cambridge Observatory, and Calculation of Results from Observations.* By the Rev. James Challis, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge.

(*Continued from the Monthly Notices for April, page* 210.)

II. *Observations of the Times of Beginning and Ending of the Eclipse.*

The chronometer time of the beginning of the eclipse was $23^h\ 14^m\ 23^s{\cdot}0$, and that of ending $1^h\ 49^m\ 52^s{\cdot}4$. Mr. Breen noted that the moon's limb had perceptibly advanced on the sun when first seen, and from afterwards noticing the impression on the sun's limb a few seconds before the end of the eclipse, he estimated the error of the time of commencement to be three or four seconds. The observed time of ending was thought to be exact to the tenth of a second. The chronometer was compared with the transit clock four times in the interval from $22^h\ 48^m$ to $2^h\ 11^m$ sidereal time, and the error and rate of the transit clock were found, by exact reduction of the transits of known stars on March 13th, 15th, and 16th. It was thus ascertained that the chronometer was $12^s{\cdot}98$ fast at $0^h\ 35^m\ 22^s$ sidereal time, and that it had a losing rate of $0^s{\cdot}175$ per hour. Hence, assuming the longitude of the Cambridge Observatory to be $22^s{\cdot}75$ east, the following results may be obtained:—

	Cambridge Sid. T. h m s	Greenwich M. T. h m s	
Beginning of the Eclipse	23 14 9·78	23 42 38·43	(probably 4ˢ late)
Ending of the Eclipse	1 49 39·64	2 17 42·81	(very exact).

Calculating from these data by the formulæ which I have given in the appendix to the *Nautical Almanac* for 1854, I obtained the following equations, involving small unknown corrections, which the quantities employed in the calculation may require:

$$+ 7''\cdot72 = -0\cdot784\,x + 0\cdot637\,y + 0\cdot776\,e - 0\cdot631\,f - 0\cdot408\,t - 0\cdot530\,\tau - 0\cdot007\,\nu + 1\cdot628\,m - 0\cdot963\,n - 0\cdot966\,n'$$

$$- 1''\cdot69 = +0\cdot778\,x - 0\cdot642\,y - 0\cdot771\,e + 0\cdot636\,f + 0\cdot428\,t + 0\cdot530\,\tau + 0\cdot001\,\nu - 2\cdot682\,m - 0\cdot963\,n - 0\cdot966\,n'.$$

In these equations x and y are the corrections in seconds of arc of the tabular values of the moon's geocentric R.A. and N.P.D., e and f the same for the sun, t is the correction of the time of observation, τ and $-\nu$ are the corrections of the assumed longitude and latitude of the observatory, 0·001 Pm and 0·001 Sn are respectively the corrections of P and S, the moon's parallax and semidiameter, and 0·001 $s\,n'$ is the correction of s, the sun's semidiameter. The tabular quantities relating to the moon were interpolated to second differences from the *Nautical Almanac*, but the assumed semidiameter is the interpolated value corrected by $-0''\cdot33$ to make it agree with the results of Cambridge observations. The assumed semidiameter of the sun is Bessel's value, which is less than that now used in the *Nautical Almanac* by $0''\cdot92$. If the latter value had been adopted, the left-hand sides of the equations would have been $+ 8''\cdot61$ and $- 0''\cdot80$. The ratio of the earth's axes employed in the calculations is that of 298 to 297.

Since it is known that e and f are very small quantities, their coefficients may be taken to be the same as those of x and y. Also it will be assumed that $\tau = 0$ and $\nu = 0$; and that the value of the moon's parallax is so well ascertained that without sensible error $m = 0$. Then putting $t = -4^s$ in the first equation, to take account of the estimated error of the time of observation, and $t = 0$ in the other, we shall have,

$$+ 6''\cdot09 = -0\cdot784\,(x-e) + 0\cdot637\,(y-f) - 0\cdot963\,n - 0\cdot966\,n'$$
$$- 1\cdot69 = +0\cdot778\,(x-e) - 0\cdot642\,(y-f) - 0\cdot963\,n - 0\cdot966\,n'$$

These equations give by subtraction and addition,

$$- 7''\cdot78 = 1\cdot562\,(x-e) - 1\cdot279\,(y-f)$$
$$+ 4\cdot40 = -1\cdot926\,n - 1\cdot932\,n', \quad \text{very nearly.}$$

III. *Observations of Transits of Limbs.*

Only two sets of transits of limbs could be taken, which, however, were considered very good. In these observations the limbs were brought to the middle of the field of view, and as the polar axis has been adjusted a short time before, the resulting differences of R.A. may be considered to be free from any error in the equatoreal adjustment of the wires.

	(1.)	(2.)
	h m s	h m s
Chronometer time of transit of ⊙'s 1 L.	0 58 56·8	1 0 10·9
" " ☽'s 1 L.	0 59 30·0	1 0 45·9
Difference of transits	33·2	35·0
Sidereal time of transit of ☽'s 1 L. ...	0 59 17·1	1 0 33·0
Corresponding Greenwich M.T. ...	1 27 28·5	1 28 44·2
Difference of R.A. of the Limbs in arc at that time by observation	496″·82	523″·74
Difference of R.A. by tabular calculation ...	498·69	523·15
Correction of calculation ...	−1·87	+0·59

In deducing the difference of R.A. of the limbs, from the difference of times of transit, the sun's motion was taken into account, and the slight correction required for refraction was applied. The theoretical difference of R.A. was calculated from the tabular values of the *Nautical Almanac* (the sun's semi-diameter being corrected by − 0″·92), and the formulæ in the appendix to the *Nautical Almanac* of 1854 were employed in the calculation.

IV. *Micrometer Measures of Differences of N.P.D. of the Cusps.*

Before the commencement of the eclipse Mr. Breen very carefully adjusted the micrometer wires equatoreally by means of the sun's limb. The two wires are very exactly parallel. The measures were taken by placing the wires simultaneously on the two cusps. This method is not so trustworthy as that of bisecting the cusps separately at the middle of the field, and noting the time of each bisection. It admitted, however, of greater expedition, which, on account of the uncertainty of the sky, was an important consideration. A short time before the central phase of the eclipse the micrometer eye-piece, and the brass tube carrying it were removed, for the purpose of viewing the physical phenomena with a Huyghenian eye-piece, and were afterwards replaced approximately in the former position. In the hurry of taking measures in the short interval during which they were practicable previous to the ending of the eclipse, the exact adjustment of the wires equatoreally was omitted, and the error of position was not subsequently determined. The value of one revolution of the micrometers had been well ascertained, and coincidence readings of the two wires were taken at the time. The measured differences of N.P.D. corrected for

refraction, and the results of comparing them with the differences of N.P.D. calculated by theory for the respective times of observation, are as follows:

Chron. Time of Bisection.	Cambridge Sid. Time.	Greenwich Mean Time.	Observed Difference of N.P.D. of Cusps.	Calculated Difference.	Corr. of Calculation.
h m s	h m s	h m s	″	″	″
23 16 18	23 16 4·8	23 44 33·1	326·54	353·58	−27·04
23 19 12	23 18 58·8	23 47 26·7	516·11	531·16	−15·05
1 48 22	1 48 9·2	2 16 12·6	303·62	289·46	+14·16
1 49 3	1 48 50·2	2 16 53·5	231·43	210·30	+21·13

Note. The 1st, 3d, and 4th measures were marked "good."

The theoretical differences of N.P.D. were calculated by a formula which may be obtained as follows. Adopting the notation of the memoir already referred to, let γ and λ be the apparent N.P.D. of the centres of the sun and moon, η the difference of their apparent R.A. in arc, d the difference of their apparent N.P.D., and c the arc joining the centres. Then χ being the angle which this arc makes with the circle of declination through the moon's centre, with sufficient approximation,

$$\tan \chi = \frac{\eta}{d} \sqrt{\sin \lambda \sin \gamma} \text{ and } c = d \sec \chi.$$

Also S and s being the semidiameters of the moon and sun, and ω the angle which the arc joining their centres makes with the arc joining the sun's centre and one of the cusps, to the same approximation,

$$\cos \omega = \frac{c^2 + s^2 - S^2}{2\,c\,s}.$$

The angles χ and ω being thus found, the difference (Δ) of the N.P.D. of the cusps is given by the equation,

$$\Delta = 2\,s \sin \omega \sin \chi.$$

The small corrections applied for refraction in N.P.D. took into account the circumstance that the two cusps were bisected simultaneously. One part of the correction was consequently the differential refraction proportional to Δ, the hour-angle being given, and the remaining part the differential refraction proportional to the difference of R.A. of the cusps, viz., $\Delta \cot \chi$, the N.P.D. being given.

V. *Micrometer Measures of the Differences of N.P.D. of the South Cusp and the Sun's South Limb.*

The micrometer measures were reduced to arc in the manner already stated. The following is the comparison of the observed differences of N.P.D., corrected for refraction, with the differences calculated by theory.

Chron. Time of Bisection. h m s	Greenwich Mean Time. h m s	Diff. of N.P.D. of Cusp and Limb by Observation. ″	Calculated Difference of N.P.D. ″	Correction of Calculation. ″
23 22 45	23 50 59·1	86·19	82·75	+3·44
23 30	51 44·0	79·97	75·02	4·95
24 20	52 33·8	70·13	67·15	2·98
25 0	53 13·7	65·67	61·31	4·31
26 23	54 36·5	54·76	50·59	4·17
27 0	55 13·4	48·65	46·29	2·36
27 59	56 12·2	41·72	39·99	1·73
28 48	57 1·1	36·46	35·25	1·21
29 36	57 49·0	32·26	30·98	1·28
30 37	58 49·8	27·30	26·08	1·22
31 27	23 59 39·7	23·68	22·47	1·21
32 8	0 0 20·5	21·72	19·72	2·00
32 42	0 54·4	18·86	17·66	1·20
34 5	2 17·2	14·83	13·15	1·68
34 40	2 52·1	12·15	11·44	+0·71
35 25	3 37·0	8·95	9·53	−0·58
36 30	4 41·8	6·22	7·07	0·85
37 15	5 26·7	4·44	5·61	1·17
23 38 57	0 7 8·5	0·55	2·97	−2·42

The Cambridge sidereal times of observation may be obtained from the chronometer times, by subtracting from the latter $13^s{\cdot}2$. The analytical expression for the difference between the N.P.D. of the cusp and the N.P.D. of the limb, is $s - s\cos(\chi - \omega)$, or $2s\sin^2\frac{\chi-\omega}{2}$, by which the theoretical values were calculated, after obtaining χ and ω by the process indicated above. The corrections applied for refraction were taken proportional to the observed difference of N.P.D., the hour-angle being given, and to the difference $s\sin(\chi - \omega)$ of R.A., the N.P.D. being given.

VI. *Micrometer Measures of the Differences of N.P.D. of the North Cusp and the Sun's North Limb.*

Chron. Time of Bisection. h m s	Greenwich Mean Time. h m s	Diff. of N.P.D. of Cusp and Limb by Observation. ″	Calculated Difference of N.P.D. ″	Correction of Calculation. ″
1 37 17	2 5 9·4	49·61	41·37	+ 8·24
38 55	6 47·2	61·80	53·57	8·23
40 51	8 42·9	82·09	71·36	10·73
1 42 22	2 10 13·6	99·76	88·56	+11·20

The sidereal times of bisection are inferred from the chronometer times by subtracting $12^s{\cdot}8$. The theoretical difference of N.P.D. and the corrections for refraction were calculated precisely as those of the preceding series.

For the sake of expedition in performing the foregoing calculations, the values of $\eta \sqrt{} \sin \lambda \sin \gamma$ and d, and those of S and s, were first calculated for nine epochs separated by intervals of half-an-hour, commencing with March 14, 23^h, and ending with March 15, 3^h. The values for the respective Greenwich mean times were then obtained by interpolations, which were extended to third and fourth differences whenever these were significant. The accuracy of this process was tested by finding values of c and χ for the beginning and ending of the eclipse, in accordance with values especially calculated for these two cases.

Also the corrections for refraction were obtained by interpolation, after calculating for the positions of the sun and moon at the above-mentioned epochs, the differences of refraction corresponding to 10′ difference of N.P.D., the hour-angle being given, and to 30^s difference of R.A., the N.P.D. being given.

VII. *Formation of Equations for Finding Small Corrections of the quantities employed in the Theoretical Calculation.*

The only quantities it is proposed to correct are the differences of the geocentric R.A. and N.P.D. of the centres of the sun and moon, and the assumed values of their semidiameters.

From the equations of condition, Professor Challis deduces the following values of the corrections referred respectively to Burckhardt's and Hansen's Lunar Tables :—

	Burckhardt.	Hansen.
Correction of the tabular distance of the R.A. of ☉ and ☽	− 3″·08	+ 4″·79
N.P.D.	+ 3″·97	+ 0″·86
Correction of the Moon's semi-diameter in the *Nautical Almanac*	− 2″·96	
Sun's	− 0″·99	

Account of Photometric Experiments made at Clapham under the Direction of the Rev. C. Pritchard, M.A. F.R.S., on the Day of the Solar Eclipse, March 15, 1858.

A board of about one foot square was placed vertically, so as to face the sun when in the meridian. This board was covered with white paper and adjusted at such a height from the ground that its centre was exactly as high as the eye of the observer. Against this board abutted the end of a horizontal levelling staff, graduated to tenths of feet in its coarser divisions. The whole was so arranged that the observer moved with his right eye along the staff and his left facing the centre of the board.

A considerable number of exactly similar pieces were cut out of the leading articles of the *Times* newspaper; and these pieces, by the aid of two drawing-pins, could be easily affixed to the board, one after the other, in precisely similar positions near to its centre.

The observer moved with his right eye close to the staff until he could with comfort distinctly read the five lines of type placed as before described. The observations were repeated every ten minutes, excepting when near to the time of the greatest obscuration of the sun, and then at intervals of five or of two and a half minutes. The results are as follows:—

Hour.	Distance of Eye.	Remarks.
h m s		
11 30 0	5 feet	Sky cloudy, and a *very* slight haze over the sun.
11 40 0	5·1	Sky cloudy, but less haze over the sun.
50 0	5	Clouds rapidly forming, and thick haze over sun.
12 0 0	5	Quite overcast; cumuli in N. and N.W.; strati, N.E. to W.
12 10 0	5	Cumuli in N. and N.W; strati, S. to S.W.; thick haze in zenith.
20 0	4·7	Cumuli N. and N.W.; strati, E.; thick over head.
30 0	4·75	An increased darkness perceptible; clouds darker in north than southern horizon.
40 0	4·5	Quite overcast; darkness certainly increasing.
50 0	4·31	A perceptible fall in the wind, with slight gusts.
55 0	4	Clouds assuming a lurid and sickly colour; air generally still, with a sort of heavy feeling.
57 10	4	Feelings of cold experienced by every one about; pigeons and other birds flying with evident uneasiness.
1 0 0	3·9	An evidently increased obscurity; cumulo-strati N. and N.W.
1 2 50	4·2	
5 0	4·4	Though not less cloudy, it brightened up very perceptibly. At 1h 8m the sun visible. Cusps very sharp, with a power of 260 and aperture 6·6 inches.
10 0	4·55	Quite overcast; strati all over horizon.
20 0	5	Cumulo-strati in E. Cirro-strati in S.
40 0	5	From 1h 35m to 3h P.M. rain.

From these observations it appears that, supposing the distinctness with which a given piece of writing may be read varies inversely as the square of the distance and directly as the illumination of the writing; then the amount of light lost at the greatest obscuration of the sun was $\frac{2}{5}$ths that of the unobscured illumination. It was impossible to mistake the sensation of the *rapidity* with which the general increase of light was regained.

Observations of the Annular Solar Eclipse of March 14–15, 1858.

Made at Peterborough, by William Lloyd Wharton, Esq.

(*Extract of a Letter to Professor Temple Chevallier.*)

"... I suspect that very few persons stationed within its central zone saw the eclipse of March 15 under such favourable circum-

stances as myself. After a long and anxious look-out from the south end of the Peterborough railway station for any appearance of the sun, I noticed, shortly before 1 o'clock, and in the midst of the very remarkable gloom which prevailed at the time, some slight openings in the clouds, through one of which the sun was very distinctly visible for some 15 or 20 seconds. Being furnished with an excellent little telescope (magnifying about 15), and able to rest it firmly against a pier of the station, I saw through it Baily's beads, I should imagine, to the utmost perfection, the thin passing cloud rendering any coloured eye-glass unnecessary.

"I am unable to describe their beauty, projecting to the number of some six or eight from each cusp of the sun, and resembling little irregular and constantly increasing and decreasing globules of bright quicksilver. (I shall presently give you another illustration.) The sky, after the above interval, became obscured for about a minute, when another break in the clouds exhibited for some 5 to 10 seconds *the perfect annulus* to the naked eyes of some two or three hundred spectators around me, and who, as it were, by one common impulse, greeted the phenomenon with a cheer of delight. On looking at the annulus through my telescope, I found the beads had vanished, being replaced by a well-defined continuous ring of light.

"The sky became again obscured, and I saw no more of the eclipse, congratulating myself, however, upon my extraordinary good fortune in observing it to the utmost advantage within the five minutes when it was peculiarly interesting.

"In walking some two or three Sundays afterwards to the Abbey, along the river-bank at Durham, I observed the sun shining brightly upon the irregular surface of the water, falling over the edge of the dam or weir across the river some 150 yards south of the place of observation. On arriving at the same spot on two or three successive Sundays, I was, on each occasion, very forcibly reminded of the Baily's beads of the eclipse by the line of little tremulous reflexions of the sun upon the edge of this weir; and believe that no better illustration of them can be discovered than the line of radiant sparks which may be observed on the upper edge of an artificial dam of water under similar circumstances."

The following is the substance of observations of the Solar Eclipse of March 15, which were forwarded to the Astronomer Royal from various parts of the country:—

Major-General Oliver observed the eclipse at London, and forwarded results of observations with the aneroid barometer and thermometer, and also results of observations for ascertaining the amount of humidity in the atmosphere.

Observed at Dunmow, Essex, by H. Eden Cockayne, Esq.

The thermometer fell about 10° in the sun, being 58°·5 before the eclipse commenced, and 48° from one o'clock to half-past one. In the shade it fell 4°. The barometer appeared slightly to rise.

Observed at Litlington Vicarage, near Basingbourne, by the Rev. J. Power.

"The obtusity of the cusps in the middle of the eclipse, compared with their well-marked acuteness a little before and a little after, was observed by our whole family party on my calling on them to notice the phenomenon. I suppose this arises from a lunar atmosphere, but there was certainly not a trace of polarization."

Observed at Ramsgate, by Robert Cramp, Esq.

Mr. Cramp forwarded results of observations with a self-registering thermometer. They commenced at $11^h\ 46^m$ A.M., and terminated at $2^h\ 30^m$ P.M.

Observed at the Devil's Dyke, near Brighton, by P. S. Rickardo, Esq.

Mr. Rickardo sent results of observations with the thermometer and hygrometer. His daughter informed him that at Brighton, where the eclipse was seen more favourably, she saw the *entire* disk of the moon between half-past twelve o'clock and one o'clock.

In the evening, about half-past eight o'clock, one of the tutors in Mr. Rickardo's establishment was on the cliffs at Worthing, and saw a fire-ball of the size of a cannon-ball, $3\frac{1}{2}$ inches in diameter. He is unable to state exactly whence it fell, as, when his attention was attracted by the flash of light, it had already begun to move; but it appeared to him about 60° from the southern horizon, falling in a south-west direction, and burning with a blue light (not unlike burning zinc), and changing into violet. It constantly decreased, and passing under a dark cloud below which it reappeared, finally vanished without noise about 8° from the south-west horizon. The whole duration of the phenomenon amounted to five seconds. There were several persons present who witnessed the phenomenon, and whose observations fully agreed with his own.

Observed at Hardingham Rectory, Norfolk, by the Rev. Challis Paroissien.

The eclipse was well seen until the moon reached the group of spots near the centre of the solar disk. Afterwards the clouds became more dense, but still the sun continued to reappear at intervals of two or three minutes. A little before the time of

greatest obscuration, the clouds cleared away, and the thin crescent was brightly and distinctly seen. I soon witnessed, as I imagine, the appearance which is usually described as 'Baily's beads.' The cusps were evidently divided, as I have endeavoured to represent them in the accompanying rough sketch.* There were three upon one of the cusps, and two upon the other. They appeared, disappeared, and reappeared three or four times. They seemed as if caused by the peaks of lofty mountains on the moon's surface with the sun seen through the intervening spaces between them. The remaining portion of the crescent was brilliant, continuous, and without interruption.

"When a considerable portion of the sun had reappeared, I observed distinctly a circular band, as represented in sketch 2, surrounding the portion of the moon's dark limb that was projected on the solar disk. Could this be the boundary of an atmosphere surrounding the moon? The space included between this circle and the dark edge was the slightest possible shade darker than the sun's disk. This circle or band continued distinctly visible until after the group of spots had reappeared. A thick cloud then intervened, and the termination of the eclipse was entirely lost to us. At the time of greatest obscuration, it was sufficiently clear to observe the dull leaden appearance of the violet sky in the zenith and in the north. It seemed very near upon the earth.

"I also observed at this time an apparent alternate contraction and elongation of one of the cusps, as if some undulating surface of land of lower elevation than the mountains were passing in review between the spectator and the sun."

Observed at Ramsgate, by Captain Martin, Harbour Master.

The phenomenon was observed with a four-foot telescope. The variations of the barometer and thermometer were noted. During the whole time the observer had three highly sensitive compasses and four dipping needles, and a powerful magnet weighted to its extreme capability, but there was apparently not the slightest influence exerted on them during the eclipse.

Observed at Colchester, by J. A. Tabor, Esq.

The indications of the barometer and thermometer were noted, and the results forwarded to the Astronomer Royal, but the state of the weather was not favourable for observing the eclipse.

Observed at Peterborough, by George S. Lefevre, Esq.

"I was stationed on one of the smaller towers of Peterborough Cathedral. From the commencement of the eclipse till a short time before its close, the sun was frequently visible at intervals

* This sketch, and the other referred to afterwards, will be exhibited at the next meeting of the Society.

varying from two to five minutes, and for periods varying from one to four seconds. The clouds, which were rolling quickly over the sun's face, formed a natural shade for the eye, and once only was the brightness such as to make it necessary to use a coloured glass, and then only a pale yellow single glass. The sun was on that occasion more than half covered, and the sky around it for the nonce was blue. At other times the sun was of a very pale colour, and could hardly be seen through a red glass. The sun was plainly visible about three minutes before the maximum of obscuration, and then again for about two seconds when the annulus was complete, and to all appearance uniform. It was also plainly and distinctly visible to the naked eye without the use of a coloured glass. The clouds then closed over it again, and when next visible the moon had again crossed the edge of the sun."

Observed at Figheldean Vicarage, Amesbury, Wilts, by the Rev. Henry Caswall.

"My observation was made without a telescope, and while standing and moving in the street at Devizes. I went to Devizes with the hope of witnessing the eclipse; but after seeing the earlier part of it five or six times, the clouds took away all hope of observing the annularity. Suddenly and unexpectedly they cleared away sufficiently to enable me to see the most interesting part, while at the same time the haze obviated the necessity of using coloured glass.

"The town clock pointed to about two minutes to one, when the growing darkness greatly increased. I saw many people in the market-place looking upwards, all with solemn countenances, in the direction of the sun, which was just struggling through the clouds. I passed onwards, still looking at the sun, for about another minute, when *suddenly* the thin crescent rapidly extended itself. For an inconceivably minute portion of time it took the form of Fig. 1, there being a break at *a*, as if from an inequality in the surface of the moon or the sun. I could not, of course, determine which. At the same instant, the isolated part at *b* seemed to *blaze*. This may possibly have been occasioned by a break, or partial break, in the cloudy haze at that moment, or from a depression on the moon's surface allowing a greater flood of light to pass than at other parts of the crescent. It did not strike me as corresponding with the phenomena described as Baily's beads; but the *fact* of a superior

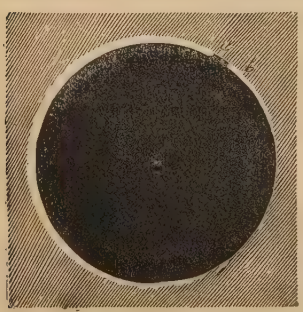


Fig. 1

brilliancy (a *white* blaze) at that point is certain. In less than a second the circle was formed, as at Fig. 2, with an effect like

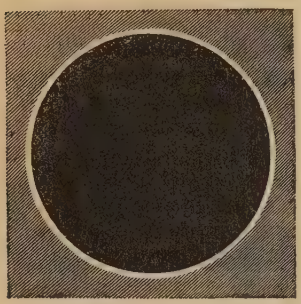


Fig. 2

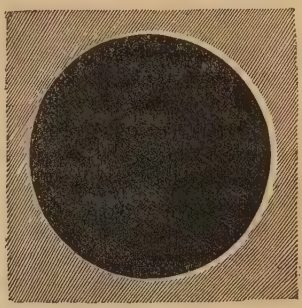


Fig. 3

that of a mechanical movement, so rapidly did it take place. I made involuntarily a loud exclamation of astonishment, which directed the eyes of the people in the street to what was going forward. As I was gazing upon it in intense admiration, the circle suddenly broke, and the crescent appeared reversed, Fig. 3, as if by another mechanical action. I saw no interruption (as before at *a*). Immediately a flood of light seemed to diffuse itself, and the next minute the light was fully equal (apparently) to that of a not very bright day.

"I do not think the annulus continued more than four or five seconds. I could not have taken more than half-a-dozen steps during its continuance."

Observed near Laycock Abbey, Wilts, by J. D. Smith, Esq.

"I am desirous of placing an observation made during the eclipse on record if it be of any value. I am not aware of the phenomenon having been previously noticed.

"About $0^h\ 54^m$ on the 15th of March, the darkness rapidly increasing, both my brother and myself were distinctly impressed with the conviction that the withdrawal of light was not continuous but by pulsations, or, as it were, waves of obscuration, the darkness increasing by strokes which sensibly smote the eye, and were repeated distinctly some five or seven times after we had remarked the phenomenon and before the time of greatest obscuration. This did not occur on the return of the light, which came back continuously and without shock or break."

The following photographs of the eclipse, which had been transmitted to the Astronomer Royal, will be exhibited at the next meeting of the Society :—

1. Five photographs of the eclipse taken during different stages of its progres (including the phase of maximum obscuration), by Mr. R. Cade, of Ipswich.

2. A photograph of the eclipse, taken at $2^h\ 10^m$ P.M. (the only time which was found favourable for the purpose), by Mr. W. Sherlock, of Lawn Cottage, Dawlish, Devon.

On the Determination of the Longitude of the Observatory of Edinburgh by Galvanic Signals of Star-Transits. By the Astronomer Royal.

During the Easter recess of the Houses of Parliament, it was thought desirable to make an attempt, by means of telegraph-signals, to re-determine the longitude of the Edinburgh Observatory, the demand for the transmission of business signals at night being less continuous then than at other times of the session, and the Electric and International Telegraph Company being able to guarantee the uninterrupted use of the wire during a limited time for an hour preceding and an hour following midnight.

The week chosen for the observations was that commencing with Monday, April 5, of the present year, and terminating with Saturday, April 10; and there is no doubt that, if the weather had been moderately good, a result of very great accuracy would have been obtained, the arrangements at each observatory being faultless, and the registers of all the stars that were visible being made on each recording apparatus without any failure. It unfortunately happened, however, that at Greenwich the weather during the greater portion of the week was exceedingly bad, clouds almost constantly covering the sky, and heavy rains falling during several of the nights appropriated to the observations. On Saturday, April 10, the sky was, however, quite clear, and the results unexceptionable, and these it is proposed to present to the Society.

A little difficulty was apprehended on account of the circumstance that the wire leading from Greenwich to Lothbury, along the South-Eastern line of railroad, was very defective (from injury by a thunder-storm, which hitherto it has not been practicable to remedy), and that it became necessary to use the wire leading from Blackheath to the Admiralty, whose insulation, though superior to that of the South-Eastern line, is not quite perfect. This difficulty was, however, completely obviated by the kindness of Mr. C. F. Varley, of the Lothbury Station, who, with a disinterested zeal which cannot be too warmly acknowledged, proposed that his brother, Mr. Alfred Varley, should attend at the Greenwich Observatory each night during the observations with a speaking and printing instrument, so as to communicate when necessary with the persons employed at Edinburgh, and should also mount and adjust a relay of great delicacy

for receiving the currents sent from Edinburgh, as it was in this case that failure was apprehended in the working of the Greenwich relay.

The long wire from Lothbury to Edinburgh appeared to be in an excellent state of insulation.

About two hundred pairs of plates were used at each end. Much smaller batteries would have sufficed if we had been satisfied with the insulation of the Blackheath Admiralty wire.

The method employed was that which has been used with so much success in the operations of the American Coast Survey. When a selected star passes one of the wires of the transit-circle at Greenwich, the observer, by a touch, completes a galvanic circuit which sends a current from the Greenwich battery through the Greenwich apparatus, and also through the Edinburgh apparatus. As this current in so long a line is too weak to make an impression on the recording apparatus, its office is confined to the completing of the circuits of local batteries (by the mechanism called the "relay"), which are perfectly able to make impressions. Thus every wire-transit of the star observed at Greenwich was registered both at Greenwich and at Edinburgh. When the same star passed each of the wires at Edinburgh, the observer there, by a touch, completed a galvanic circuit from the Edinburgh battery through the Edinburgh apparatus and also through the Greenwich apparatus, which completed the circuits of the local relays and batteries, and thus every wire-transit of the star observed at Edinburgh was registered both at Edinburgh and at Greenwich. At each place, therefore, there were complete means for determining the difference of longitude without reference to clock-stars, clock-errors, &c., and by the most direct comparisons of transits of the same star that are possible. But there is this difference between the two records, that in one the intervals are increased by duration of passage of the galvanic current, in the other they are diminished.

As it was found desirable to use at Greenwich one relay for the out-going currents (which were stronger), and another for the in-coming currents (which, in consequence of the slight imperfection of the near wire, were weaker), I think it right to state that no sensible error on the longitude needs be feared on that score. Experiments which I once made with Mr. Latimer Clark showed that the loss of time in a relay is only about $\frac{1}{50}$th of a second; and as the possible error is only the possible variation on that $\frac{1}{50}$th of a second, it may at once be dismissed from our minds.

The stars employed for signalling were 22 in number, arranged in three groups, so that the intervals of transits from the first to the last star of each group should be a few minutes less than the difference of longitude of the two observatories, and that the interval between the last star of one group and the first star of the next should be a few minutes greater than that difference. By this arrangement all the stars of any group, after transiting the meridian of Greenwich, could be conveniently observed over that

of Edinburgh, time being left after the transit of the last star at Greenwich, to make the proper changes in the wire-connexions for receiving signals from Edinburgh.

Professor Smyth had provided a fillet recording apparatus, by means of which his own transits, as well as those received from Greenwich, were registered, while at Greenwich the recording cylinder, used in the ordinary transit observations, was employed. The difference between these two kinds of apparatus produces no effect on the determination of longitude, because at Edinburgh the same recorder was used whether the transits were observed at Edinburgh or at Greenwich; and a similar remark applies to Greenwich.

The results deduced were as follows:—

From the registers at Edinburgh of the two sets of transits (namely, Edinburgh transits and Greenwich transits), the differences of longitude were—

	m	s		m	s
By 27 Comæ	12	42·98	By *e* Virginis	12	43·02
35 Virginis		43·13	*σ* Virginis		42·83
29 Comæ		43·09	62 Virginis		42·99
B.A.C. 4306		42·92	B.A.C., 4468		43·02
37 Virginis		42·99	B.A.C., 4547		42·99
38 Virginis		43·07	B.A.C., 4554		43·13
ψ Virginis		42·97	B.A.C., 4560		43·07
δ Virginis		43·03	*m* Virginis		42·83
B.A.C., 4423		43·08	*o* Virginis		43·11
56 Virginis		43·01	B.A.C., 4578		42·87
B.A.C., 4436		42·99	87 Virginis		42·99

Mean = $12^m\ 43^s{\cdot}005$

From registers at Greenwich of the same two sets of transits (excepting 27 *Comæ*) the differences of longitudes were

	m	s		m	s
By 35 Virginis	12	43·20	By *σ* Virginis	12	42·99
29 Comæ		43·17	62 Virginis		43·08
B.A.C., 4306		43·03	B.A.C., 4468		43·08
37 Virginis		43·06	B.A.C., 4547		43·05
38 Virginis		43·17	B.A.C., 4554		43·21
ψ Virginis		43·03	B.A.C., 4560		43·16
δ Virginis		43·08	*m* Virginis		43·02
B.A.C., 4423		43·16	*o* Virginis		43·17
56 Virginis		43·10	B.A.C., 4578		42·95
B.A.C., 4436		43·03	87 Virginis		43·07
e Virginis		43·11			

Mean = $12^m\ 43^s{\cdot}091$

Hence the result for longitude independent of retardation of current, but still subject to relative personal equation of observers, is $12^m\ 43^s{\cdot}048$.

And the retardation of current between the two observatories is $0^{s}.043$.

Professor Smyth acknowledges in warm terms the important services rendered at his end of the line by the telegraph officers, and in particular by the local superintendent, Mr. R. S. Culley, who, he says, "managed the whole electrical arrangements for us, and went at it thoroughly *con amore*." In fact, without the disinterested and cordial co-operation of all the authorities at both ends of the line, the experiment could scarcely have been carried through at all, and certainly not with the remarkable success which attended it on the only evening on which the state of the sky rendered observations possible.

Note on the Projection of the Great Circle.

By Sir John W. Lubbock, Bart.

"Allow me to suggest that in practice the great circle can very easily be laid down on Mercator's or any other projection, by first laying it down on a map on the gnomonic projection, in which it is a straight line (those published by the Society for the Diffusion of Useful Knowledge are very cheap and easily procured), and then copying it on the other projection. If a circular arc be a sufficient approximation, then if one intermediate point only be ascertained and laid down on Mercator, a circular arc can be drawn through it and the extremities by the well-known rule."

The Fellows of the Society, we are assured, will learn with deep regret that our illustrious Associate, M. F. W. Struve, the Director of the Imperial Observatory of Pulkowa, has for some time past been labouring under an attack of illness of so serious a nature as to have caused much anxiety to his family and friends. Letters, however, have recently been received by the Astronomer Royal from M. Otto Struve, by which it is gratifying to find that the health of his father had undergone a favourable change, and strong hopes were entertained of his ultimate recovery. The following passages extracted from one of these letters, dated May 10, contain some interesting intelligence :—

"Most probably my father will have informed you last year of the intended erection of a splendid observatory at Lisbon, for which we are asked to co-operate, particularly with regard to the ordering of instruments. The great instruments, a 15-inch refractor, a prime vertical transit, and a meridian circle, are all ordered at Repsold's, with the object-glasses from Merz. Lately there have been negotiations respecting the minor instruments."

In a memoir of June 30, 1857, M. Otto Struve refers in terms of strong approbation to the timekeepers constructed by Messrs. Frodsham and Dent, of whose eminent abilities as artists ample proof had been experienced at the Pulkowa Observatory. The Commission charged with the erection of the Portuguese Observatory, have accordingly resolved to procure the clocks for the establishment from Mr. Dent, subject to the verification and approval of the Astronomer Royal.

"Your new equatoreal," proceeds M. Struve, "I trust, will be the most perfect existing specimen of English mounting. In the same way Repsold will no doubt apply to the Lisbon refractor what may be esteemed the best German mounting. In two years hence, when it is finished, we shall thus obtain a fair comparison of the relative merits of the two principles of mounting.

"The description of the chronographic apparatus will be especially interesting to us. We are about to establish at our Observatory a galvanic connexion of all the clocks, and to do so at once in a practical way your description will be of the greatest service. This application of galvanism to astronomy we have perhaps too long delayed introducing here. On the other hand, we are not yet convinced that the American method of registering transits is a real advancement in science; therefore we shall not introduce it until our misgivings on that point have been removed by experience, unless perhaps for some special problem, such as, for instance, you have indicated for observations of differences of right ascension at the opposition of *Mars*, &c. For such purposes the apparatus, I think, ought to be made transportable."

Extract of a Letter from Professor Weisse to the Astronomer Royal.

"I have recently laboured unremittingly to bring to a close my second Catalogue of Bessel's Zones. It is now completed, and is to be printed forthwith at St. Petersburg. I hope that it will be published in the course of the present year; it contains upwards of 37,000 positions. I have compared my first and second catalogues with Struve's *Positiones Mediæ*. I have discovered 1500 stars which are common to my catalogues and to Struve's, and I have calculated and noted down their differences. I shall not fail to publish this investigation. The Imperial Academy of St. Petersburg has prepared new types for my Catalogue. I am in hopes, therefore, that as a publication it will be better got up than the first was.

"The Observatory of this place, which was falling into decay, is about to undergo extensive repairs. An entirely new building would have been preferable. However, as this could not be obtained, I am glad that the instruments are to be placed on a firmer

foundation than formerly. I expect that the repairs of the Observatory will be completed in the course of the autumn."

Cracow, May 13, 1858.

Discovery of a New Comet.

On the 21st of May, Dr. Bruhns discovered at Berlin a new comet, of which he obtained the following position :—

May 21, $14^h\ 21^m\ 54^s{\cdot}8$ Berlin M.T.

	R.A.	Decl.
	$24\ 3\ 25{\cdot}4$	$+\ 39\ 57\ 52{\cdot}8$
Daily Motion ...	$\Delta\alpha$ ... $+\ 138'$	$\Delta\delta$ ... $+\ 80'$

This seems to be a different comet from that discovered by Mr. Tuttle on the 3d of the same month.

Mr. De La Rue exhibited, at the meeting of the Society, some beautiful photographs of the moon taken during different phases, and also a very striking stereoscopic view of the visible hemisphere of the same body. The globular form in the latter case was most unequivocally brought out.

RECENT PUBLICATIONS.

Osservazioni dello Ecclisse Solare del Giorno 28 *Luglio*, 1851, *fatte in Diversi Osservatorii di Europa calcolate dal Prof. Giovanni Santini.* Pp. 30. 4to. Venezia, 1856.

In this paper Professor Santini discusses the observations of the solar eclipse of 1851, made at various observatories of Europe, and by means of them forms a corresponding number of equations of condition, involving three unknown quantities, $d\lambda$, $d\beta$, and dp, in which $d\lambda$ and $d\beta$ denote respectively the corrections to Burckhardt's Lunar Tables in Longitude and Latitude, and dp the correction to the sum of the semidiameters of the sun and moon. Considering first the equations of condition depending on the observation of the eclipse made at Königsberg when the obscuration was total, he finds

$$dp = -\ 1''{\cdot}71$$
$$d\lambda = -\ 26{\cdot}54$$
$$d\beta = +\ 0{\cdot}28$$

Grouping then together all the equations of condition derived from observations made at places where the eclipse was partial,

and assuming the above value of $d\,p$ as definitive, he obtains from them

$$\delta\lambda = -28'.872$$
$$\delta\beta = +\ 0''.134$$

Combining these results with those derived from the Königsberg observation, and taking into account the number of contacts upon which the results in each instance depend, he finds

$$d\lambda = -28''.406$$
$$d\beta = +\ 0''.163$$

The substitution of the resulting values of $d\,\lambda$, $d\,\beta$, and $d\,p$, in the equations of condition, affords a satisfactory account of the residual errors.

Professor Santini concludes his paper with an investigation of the correction to the longitude of Danzig, founded on the observation made at that place, where the eclipse was total.

Information and Suggestions addressed to Persons who may be able to place themselves within the Shadow of the Total Eclipse of the Sun on September 7, 1858. Prepared by R. C. Carrington, Esq., Fellow and Secretary of the Royal Astronomical Society. Printed and Circulated by order of the Lords Commissioners of the Admiralty (pp. 32), 8vo. London, May, 1858.

As any person who may be desirous of observing the total eclipse of the sun which will occur on the 7th of September next, will have no difficulty in procuring a copy of this pamphlet, we shall merely notice one or two suggestions of general interest offered by the author, who from his experience as a practical astronomer, and the circumstance of his having been one of the observers of the total eclipse of the sun of 1851, was well qualified for drawing up such a paper as that now before us.

Mr. Carrington suggests a division of labour in observing the red protuberances usually seen during the totality of the eclipse. In order to settle definitely the question whether they belong to the sun or moon, he remarks, that one thing alone is required—the observation by a skilful astronomer, armed with a micrometer on a well-mounted telescope, of *the rate* of covering and uncovering of the protuberance by the moon's disk in its passage over the sun. It would be desirable to select a protuberance presenting a well-defined outline or point for reference to the moon's limb.

The author suggests that another observer should select the protuberance which first appears to him to offer the most characteristic features of form or colouring, and confine his attention to watching its aspect until it finally disappears on the return of the sun's light.

It is proposed to assign to a third observer the task of noting all the protuberances which may be visible at his station, recording with all the accuracy he can command the angles at which they are distributed round the disk, and the estimated greatest heights of as many as possible.

For rapid estimations he suggests inserting in the field of the telescope a circular diaphragm, having its inner edge divided by small notches into intervals of 10°, and provided with a square (formed by the intersection of two pairs of parallel wires) of a size little exceeding the computed diameter of the moon. If this square be crossed by two diagonal wires, the latter will afford a very accurate method either of adjusting the diaphragm with respect to a meridian, or ascertaining its error of adjustment. The bounding square will enable the observer with ease to keep the disk of the moon in the centre of the field.*

The author is of opinion that the red protuberances may be rendered visible when the image of the eclipsed sun is projected on a screen, if proper precautions be taken to cut off the scattered light, and he makes some suggestions with a view to that end.

Views of the protuberances are given as they appeared during the four total eclipses of 1842, 1850, 1851, and 1853.

The pamphlet contains full particulars with respect to the most convenient mode of reaching the two accessible portions of the South American Continent over which the moon's shadow will pass, the expenses of the voyage out and back, the most suitable localities as regards climate, &c. The path of the shadow over the two regions is laid down on two maps. The coast lines were reduced from the Admiralty charts, lent the author for the purpose by the Hydrographer. The central and limiting lines of the shadow were specially computed by Mr. Farley, the first Assistant on the Nautical Almanac establishment, from the Solar and Lunar Tables of Professor Hansen.

Appended to the pamphlet is a translation from the French of the account given by M. Kutczycki of the total eclipse of August 7, 1850.

It may be as well to mention that the Library of the Society contains the official account of the total eclipse of November 30, 1853, which was drawn up by M. Moesta, and addressed to the Minister of Public Instruction of Chile; it is entitled, *Informe sobra las Observacions Hechas durante el Eclipse Solar de* 30 *de Noviembre de* 1853, *presentado al Señor Ministro de Instruccion Publica, por Cárlos Moesta, Santiago de Chile,* 1854.

The account of the eclipse published in the *Monthly Notices* for June 1854, (vol. xiv. p. 225) is a translation by the Editor from the Spanish report of M. Moesta, as it appeared in a Santiago newspaper, which had been forwarded to him by Admiral Smyth, the *brochure* above mentioned not having then been received

* Mr. Carrington has given a drawing of this diaphragm at the end of his pamphlet.

at the Apartments of the Society. The Editor, however, has verified the accuracy of the account from which the translation was derived, by comparing it with the separate publication of M. Moesta, with which he found it to be in all respects identical, except that the delineation of the eclipse alluded to in the translation as wanting in the original, is given in M. Moesta's separate account. This drawing, it may be added, agrees very well with the one given by Mr. Carrington, and which appears to have been derived from Gould's *Astronomical Journal.*

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